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Late information pick-up is preferred in basketball jump shooting

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Abstract

In this study we examined the timing of optical information pick-up in basketball jump shooting using an intermittent viewing technique. We expected shooters to prefer to look at the basket as late as possible under the shooting style used. Seven experts with a high shooting style and five experts with a low shooting style took 50 jump shots while wearing liquid-crystal glasses that opened and closed at pre-set intervals. In principle, under this constraint, the participants could control when they saw the basket by actively modulating the timing of their movements. Analyses of the phasing of the movements relative to the events defined on the glasses revealed that low-style shooters preferred to see the basket just before the ball passed their line of sight, whereas high-style shooters tended to view the basket from underneath the ball after it passed their line of sight. Thus, most shooters preferred to pick up optical information as late as possible given the adopted shooting style. We conclude that, in dynamic far aiming tasks such as basketball jump shooting, late pick-up of optical information is critical for the successful guidance of movements.

Keywords: *Expert performance, far aiming, timing, visual control*

Introduction

In sports, there is an abundance of far aiming tasks, often with the purpose of scoring. Although it is evident that vision plays an important role in the control of far aiming tasks, its exact role is unclear. In static far aiming tasks, like rifle shooting, shooting free throws in basketball and playing billiards, the duration of the final fixation on the target before initiating the final movements correlates with expertise (e.g. Janelle *et al.*, 2000; Vickers, 1996; Williams, Singer, & Frehlich, 2002a). Compared with non-experts, experts fixate their gaze at the target for longer before taking the actual shot, a phenomenon called "quiet eye" (Vickers, 1996). A long target fixation has been associated with movement programming (Vickers, 1996; Williams *et al.*, 2002a). However, long target fixations have only been reported in static self-paced tasks where the positions of both performer and target are stationary. Note that physiological regulation in static tasks is often related to performance and a long fixation may enhance the state of readiness as proposed by Williams *et al.* (2002a). In dynamic far aiming tasks, like shooting at goal in soccer or basketball jump shooting, there is often no time for long fixations and thus no time for elaborate movement programming. In such dynamic tasks, the timing of optical information pick-up may well be crucial because the opportunities for information pick-up are limited and the detected information has to be used in controlling an unfolding movement given certain neuromuscular delays.

Using a visual occlusion technique, Oudejans, van de Langenberg and Hutter (2002) found that, in basketball jump shooting, players relied almost exclusively on optical information picked up late during the unfolding movement – that is, just before ball release. This finding could be at odds with Vickers' (1996) finding that free throw shooters fixate at the basket for an extended duration before movement initiation; however, this should be qualified in two ways. First, and importantly, the presence of long fixations in no way denies the possibility that a particular preferred timing of optical information pick-up exists if only limited time is available. Second, Oudejans and colleagues' (2002) finding pertained to high-style shooters and that of Vickers (1996) to low-style shooters. As we will argue, it might well be that the kinematic properties of low and high shooting styles place different constraints on the pick-up of optical information.

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With the low shooting style (cf. Kreighbaum & Barthels, 1981), ball and hands remain below eye level before the final extension of the elbow, after which they move in front of the face (see Figure 1, left). An advantage of this shooting style is that the final extension of the elbow can be initiated as soon as sufficient information has been picked up. A potential disadvantage is that information pick-up has to occur before the final extension of the elbow because the target is obscured during the remainder of the movement (cf. Vickers, 1996).

With the high style, the ball is first carried to a position above the head followed by an extension of the elbow until ball release (cf. Hay, 1973/1993). An advantage of the high style is that the shooter can look at the basket from underneath the ball when it is held overhead (Figure 1, right), allowing online visual control of the final shooting movements close to ball release, with the potential disadvantage that the time window for viewing the target becomes narrower.

Oudejans *et al.* (2002) concluded that high-style players take advantage of the possibility of late optical information pick-up, but it is unclear whether this conclusion generalizes to low-style shooters because, until now, they have not been investigated in this regard. It is important, however, to do so because the notion of quiet eye implies that optical information is being picked up from a relatively early time, leaving the possibility open that in low-style shooters late optical information is more critical in controlling the movement than early information. In low-style shooters, the ball occludes the target for only the last 123 ms before ball release (Oudejans *et al.*, 2002), which is in the same order of magnitude as the visuo-motor delays reported in the literature (Caljouw, van der Kamp, & Savelsbergh, 2004; Carlton, 1992; Michaels, Zeinstra, & Oudejans, 2001). This implies that, in principle, low-style shooters could also control their movements until ball release on the basis of the information picked up just before the ball entered their field of vision.

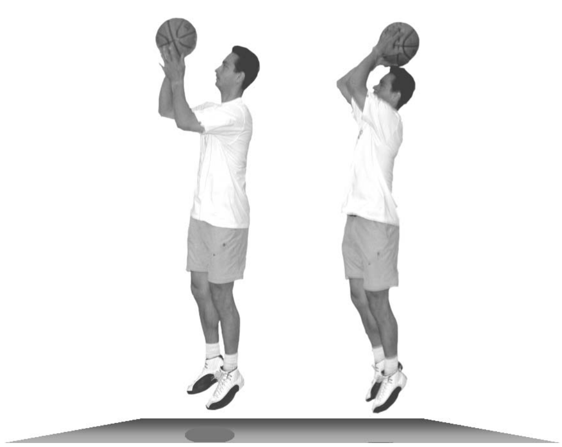

Figure 1. Image of low-style (left) and high-style (right) shooting.

One way to determine whether both high-style and low-style shooters prefer to pick-up late rather than earlier optical information is by using an experimental set-up in which participants themselves can control during which phase of the shooting movements they see the basket, thereby revealing their preferred timing of optical information pick-up. Such a strategy has been used successfully to examine the relationship between the phasing of hand movements and the pick-up of optical information in cascade juggling (van Santvoord & Beek, 1994) and one-handed catching and throwing (Amazeen, Amazeen, Post, & Beek, 1999). In both studies, the participants, who wore liquid-crystal glasses that opened and closed at pre-set intervals, coupled (i.e. phase-locked) the throws and catches of the balls to the opening and closing frequency of the glasses. A subsequent study on one-handed catching and throwing with a eye-tracker confirmed that the part of the ball flight that was visible during intermittent viewing was also the part at which the participants directed their gaze while performing the task with full vision (Amazeen, Amazeen, & Beek, 2001).

Using a similar occlusion technique, the present study was undertaken to examine the preferred timing of optical information pick-up as a function of shooting style, and to test the hypothesis that both high-style and low-style shooters prefer to pick up late optical information. In particular, we expected high-style shooters to time the moment when the ball passed their line of sight with the opening of the glasses, as this would allow them to view the basket until ball release. Conversely, we expected low-style shooters to time the moment when the ball passed their line of sight with the closing of the glasses, as this would allow them to view the basket until it was obscured by ball and hands.

Methods

Participants

Twelve experienced right-handed basketball players participated in the study. Seven participants with a high shooting style (all male) and five with a low style (one male and four female) were selected. Shooting style was confirmed after the experiment, as will be reported in the Results section. The age of the participants ranged from 18 to 39 years (mean $= 26.8$, $s = 7.9$ years) and their basketball experience from 6 to 27 years (mean $= 16.0$, $s = 7.1$ years). The two style groups did not differ significantly ($P > 0.05$) in age ($U_{(N=12)} = 13.0$) or in years of basketball experience ($t_{10} = 0.92$). All participants played either at the guard or forward position in the highest league in The Netherlands or the league just below this league, and were the best shooters of their respective teams. After a brief explanation of the experimental procedure, the participant gave his or her written informed consent. The experiment was approved by the local ethics committee before testing began.

Task

The participants, who wore liquid-crystal glasses, were asked to make a left-hand dribble, a step, a jump stop and a jump shot from a designated area on the floor. The dribble and step were included to guarantee that the shots were not taken from exactly the same position, thus ensuring that optical information about the relative location of the hoop had to be picked up afresh for each trial. These preparatory movements also ensured that the shooter had enough time available to negotiate the constraints imposed by the intermittent viewing. A full-vision control condition was not run because this data were already available for all participants from previous studies (e.g. Oudejans *et al.*, 2002; Oudejans, Koedijker, Bleijendaal, & Bakker, 2005).

Experimental set-up

The experimental set-up was identical to that used by Oudejans *et al.* (2002). It consisted of a standard basketball backboard and rim placed in a large gym-size laboratory. The initial position of the participant for each trial was about 6 m obliquely to the right of the basket. The shooting area, indicated by a 1 × 1 m square drawn on the floor, was about 5 m from the basket.

Participants wore Plato liquid-crystal glasses (Translucent Technologies, Toronto, Canada), which opened and closed at pre-set intervals. Hand and head movements were registered at 100 Hz (i.e. with a temporal precision of 10 ms) using a three-dimensional motion measurement system with active infrared markers (Optotrak 3020, Northern Digital Inc., Waterloo, Canada). Data recording could be briefly interrupted if the reflective markers were occluded from the cameras' line of sight by the ball or parts of the shooter's body. Three markers in a triangular configuration were taped to the right leg of the glasses, with the two upper markers of the triangle defining the line of sight. One marker was attached to the right ring finger.

The configuration included a host PC, an Optotrak control unit connected to the host PC and a three-dimensional sensor connected to the control unit. The position sensor was placed about 5 m obliquely behind the shooting area at a height of 2.65 m. A marker strober and a battery case for the glasses were strapped to the shooter's waist. Two cables connected to the Optotrak control unit and PC were led to the shooter's waistband via a pulley system, preventing the shooter from becoming entangled in the cables or being hindered otherwise in his or her performance.

A digital video camera was set up perpendicular to the plane of shooting to detect the moment of ball release. To synchronize the video and Optotrak recordings, a box with two red light-emitting diodes (LEDs) was placed in view of the video camera on the opposite side of the set-up. One LED indicated the start and end of each trial and the other the opening and closing of the glasses. Official FIBA regulation size basketballs (Spalding) were used according to the participant's gender.

Procedure

The experimenters taped the Optotrak marker onto the ring finger of the participant and provided instructions about the task. Participants were instructed to execute the task at their own pace. They were allowed 15 warm-up shots, also with the purpose of becoming familiar with the experimental environment. Each player then took 50 jump shots under intermittent viewing. Vision was manipulated by opening and closing the liquid-crystal glasses at pre-set cycles. During each cycle, the glasses were open for 350 ms and closed for 250 ms. These intervals were chosen based on previous results (Oudejans *et al.*, 2002; Oudejans & Coolen, 2003) indicating that, for the high-style shooters, the final period duration (the period between the moment when hands and ball pass the line of sight until ball release) lasted on average about 350 ms, while the mean duration from landing in the shooting area to the moment of ball release was about 600 ms.

At the beginning of each trial, one of the experimenters indicated when the shooter could start, while simultaneously triggering the Optotrak, the intermittent viewing and the LEDs. After the ball was shot, the glasses were opened, at which point the player returned to the starting position, and the ball was returned to the shooter by the second experimenter. For each trial, the registration period was about 6 s. Within this time the task could be executed without additional time pressure other than shooting before landing (as demanded by the rules of basketball). The success of each shot (hit or miss) was registered.

Data reduction

Shooting style was checked by calculating the viewing angles using the method described by

Oudejans *et al.* (2002). This method consisted of subtracting the angle formed by the line between the rim, the eye and the antero-posterior horizontal line from the angle formed by the tangent line to the ball through the eye and the antero-posterior horizontal line. In cases where the computation of the viewing angles was impossible due to loss of Optotrak data, shooting style was assessed by visual inspection of the video recordings of hand and head movements during shooting and by comparing the final period durations to those reported in the literature (Oudejans *et al.*, 2002). In combination, these analyses allowed us to determine whether the shooters could look underneath the ball at the basket before and during final extension of the elbow.

The moment when hand and ball passed the line of sight (mLoS) was calculated off-line on the basis of the Optotrak data by determining the sample number at which the hand marker was in line with the two markers defining the line of sight (Oudejans & Coolen, 2003). The moment of ball release was determined from video and defined as the first video image at which the hand had visibly lost contact with the ball.

To analyse the timing of mLoS relative to the events defined on the glasses, we had to take into account the cyclical nature of these events. Note that if mLoS occurred at 250, 850 or 1450 ms after the first closing of the glasses, this would be qualitatively the same because at each of these moments mLoS coincides with the opening of the glasses (Figure 2). In addition, the beginning and end of each cycle were qualitatively similar and this would not have been accounted for in a linear analysis. For this

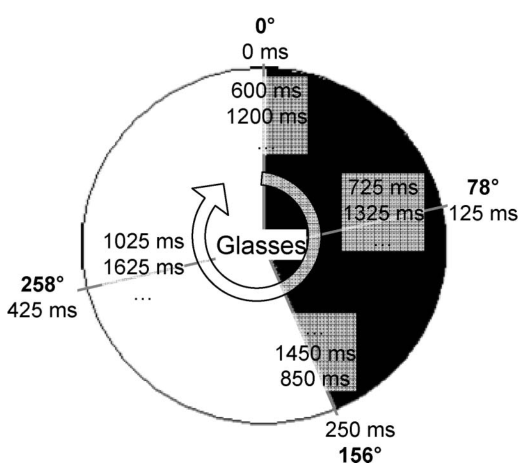

Figure 2. Conversion of the events defined on the glasses to circular coordinates (degrees). The black right side of the circle represents the closed window of the glasses (250 ms), whereas the white left side represents the open window (350 ms). A diagonal line across the diameter of the circle indicates the middle of both the open and closed windows. The intermittency is indicated by the central arrow.

reason we related mLoS to the cyclical events defined on the glasses by converting mLoS to an angle on a circle, with 0° ($=360^\circ$) corresponding to the closing of the glasses (0 ms) and 156° corresponding to the opening of the glasses (250 ms). Using circular statistics (Batschelet, 1981; Fisher, 1993), we examined the phasing (distribution and angular direction) of mLoS to determine whether shooting-style dependent timing patterns were present.

Results and discussion

Shooting style

We first verified that the shooting styles used by the 12 participants were indeed as expected. As indicated in the Methods section, this was done on the basis of an analysis of viewing angle and, if necessary, by a combined analysis of final period durations and video footage. The analysis of the viewing angles confirmed that five shooters had a high style and three a low style (see Table I). For the remaining four participants (1H, 2H, 3L, 5L), the Optotrak signal from the hand was interrupted before the final propulsion movement, rendering it impossible to estimate the viewing angle. For participant 1H, it was already confirmed in a previous study that he had a high shooting style (Oudejans *et al.*, 2002). For the remaining three participants, the final period durations indicated that one (2H) had a high style and two (3L, 5L) a low style, which confirmed the results derived from the video footage. Thus, all participants exhibited the expected shooting style.

On average, the high-style group had longer final period durations (mean = 343, $s = 50$ ms) than the low-style group (mean = 134, $s = 80$ ms) ($t_{10} = 5.59$, $P < 0.01$). This finding is consistent with the results of Oudejans *et al.* (2002), who found an average final period duration of 357 ms for high-style basketball shooters performing an identical task under full vision, and a final period duration of 123 ms for the two low-style shooters that participated in their study.

Shooting performance

To check for learning effects over trials, we computed the number of hits for every 10 trials, resulting in five 10-trial blocks for each of the 12 participants. In view of the small number of hits in each block, we conducted a χ^2-test to analyse the effects of block and shooting style. The test revealed that the number of hits did not differ significantly between blocks for both the high- ($\chi^2_{4,\ 199} = 4.4$) and low-style group ($\chi^2_{4,\ 154} = 0.68$), indicating that no learning effects had occurred across the 50 trials.

Table I. Viewing angles, final period durations and results of video footage used to determine shooting style.

Participants	Viewing angles, degrees[a] (mean ± *s*)	Final durations, ms (mean ± *s*)	Style
Low-style			
Total	−5.3 ± 2.4	134 ± 80	
3L	–	75 ± 10	Low
4L	−5.4 ± 1.7	130 ± 12	Low
5L	–	67 ± 11	Low
7L	−2.9 ± 3.0	267 ± 21	Low
11L	−21.3 ± 1.7	131 ± 14	Low
High-style			
Total	31.3 ± 6.1	343 ± 50	
1H	–	262 ± 28	High
2H	–	288 ± 14	High
6H	35.7 ± 0.1	383 ± 15	High
8H	31.5 ± 2.3	366 ± 14	High
9H	22.2 ± 0.6	335 ± 13	High
10H	37.9 ± 5.8	387 ± 11	High
12H	29.1 ± 3.5	382 ± 12	High

[a]Viewing angles were calculated as described in Oudejans *et al.* (2002). Positive angles indicate that the shooter looked at the target from underneath the ball and negative angles indicate that the ball occluded the target. –, indicates that the variable in question could not be calculated.

These group results were reflected in the data of all individual participants.

To examine the effects of the imposed intermittent viewing on task outcome, we compared the shooting percentages achieved under intermittent viewing to those that were available from previous studies with the same participants for the full-vision condition (i.e. Oudejans *et al.*, 2002, 2005). Since the shooting performances were distributed normally (Shapiro-Wilk test, $W_{12} > 0.96$, all $P > 0.05$), we used a paired *t*-test for this comparison. On this test, no significant differences were found between the shooting percentages achieved under intermittent viewing in the present study (mean 58.8%, $s = 8.2$) and those realized under full vision in previous studies (mean 61.3%, $s = 7.9$) ($t_{11} = 1.0$). Hence, under intermittent viewing, sufficient optical information was picked up to allow the participants to shoot as accurately as with full vision. In addition, an independent *t*-test revealed no significant differences between the experimental shooting percentages of the high-style group (mean 56.9%, $s = 9.0$) and the low-style group (mean 61.6%, $s = 6.7$) ($t_{10} = 0.99$), indicating that the shooting percentages of the two groups were similar.

Timing of optical information pick-up

Active phasing of mLoS. To determine whether expert shooters actively negotiated the intermittent viewing constraint, we tested the null hypothesis that mLoS was distributed uniformly along the cycle of opening and closing defined on the glasses. To this aim, we performed Rao's spacing test, which is based on the spacing between adjacent phase values. A mean distance (R) between adjacent phase values that deviates strongly from $360°/n$ implies a small probability of the data being uniformly distributed (see Batschelet, 1981, p. 66). According to Rao's spacing test, mLoS was neither randomly distributed in the low-style group ($R_{246} = 272.2$, $P < 0.01$) (Figure 3, upper left) nor in the high-style group ($R_{336} = 295.7$, $P < 0.01$) (Figure 3, upper right), indicating that both groups actively negotiated the pattern of opening and closing of the glasses.

We also examined to what extent this group effect was present at the individual level by performing Rao's spacing test on the data of each participant. This test revealed that for 5 of the 12 shooters (4L, 5L, 8H, 10H, 12H), mLoS was not randomly distributed over the cycle defined on the glasses (all $R_{>47} > 158.4$, $P < 0.05$), implying that these shooters actively negotiated the intermittent viewing constraint, whereas two shooters (3L and 9H) showed a tendency in this direction ($R_{>49} > 151.2$, $P < 0.10$). Thus, 5 (or even 7) of the 12 shooters had a preference for timing mLoS within a particular location of the glasses' cycle.

Average phasing of mLoS. After having established that, at the group level, the distribution of mLoS over the cycle of opening and closing of the glasses was not random, we examined the average phasing (i.e. central tendency) of mLoS within the cycle defined on the glasses to scrutinize whether the low-style and high-style groups indeed preferred to look at the basket as late as possible given their shooting style. In the low-style group mLoS occurred, on average, at 317.7° ($s = 106.2°$), while, in the high-style group, mLoS occurred, on average, at 162.4° ($s = 131.3°$). This difference was significant on a non-parametric circular test used for determining whether two distributions are identical (Mardia-Watson-Wheeler test, $W_{582} = 19.19$, $P < 0.01$). Given that the glasses closed at 0° (=360°) and opened at 156°, this means that in the low-style group mLoS occurred just before the closing of the glasses, permitting vision just before ball and hands occluded the target, whereas in the high-style group mLoS occurred just after the opening of the glasses, permitting vision after mLoS until ball release. Thus, the group data confirmed the expectation that shooters prefer to look at the basket as late as possible given their shooting style.

Again we examined to what extent the individual data reflected the group effects. This analysis revealed that the average phasing of mLoS was closer to the closing than to the opening of the glasses in

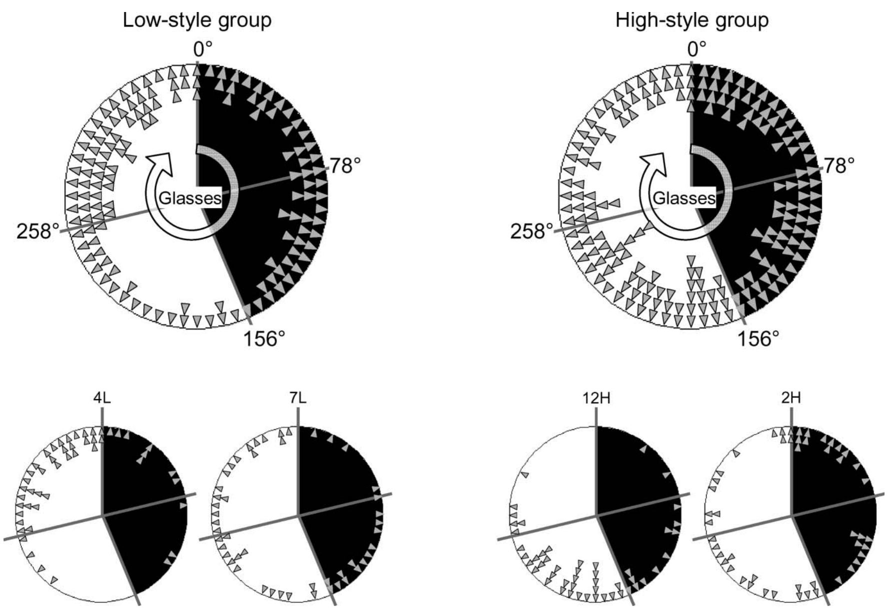

Figure 3. Distribution of mLoS (one triangle per trial) within the cycle of the glasses for both the low-style ($n = 246$) and the high-style ($n = 336$) group. Note that the low-style group has a larger concentration of mLoS at the end of the open window, whereas the high-style group has a larger concentration of mLoS at the beginning of the open window. Depicted below are the distributions of individual shooters, for the purpose of illustration. Low-style shooter 4L has a larger concentration of mLoS at the end of the open window. High-style shooter 2H has a random distribution of mLoS, therefore it is useful to know which trials resulted in hits or misses.

three (3L, 4L, 5L) of the five low-style shooters, and that the average phasing of mLoS was closer to the opening than to the closing of the glasses in three (9H, 10H, 12H) of the seven high-style shooters. As became evident in the previous analysis, these six shooters all actively negotiated the intermittent viewing (albeit with a tendency for 3L and 9H). Thus, only 8H actively negotiated the intermittent viewing without arriving at an average phasing of mLoS consistent with the expected preference for looking as late as possible.

Phasing of mLoS and shooting accuracy. Having established a preference for looking as late as possible in half of the participants, we examined whether shooting success depended on the phasing of mLoS relative to the opening and closing of the glasses in the participants who did not show a preference for looking late. In the two low-style shooters with random phasing of mLoS (7L and 11L), mLoS occurred on average closer to the opening than to the closing of the glasses in both hits and misses, implying that shooting accuracy was independent of the phasing of mLoS. In contrast, two of the three high-style shooters with random phasing of mLoS (2H and 6H) showed a significant difference between mLoS for hits and misses ($W_{>47} > 5.9$, $P < 0.05$) in that mLoS occurred closer to the opening of the glasses for the hits and closer to the closing of the glasses for the misses (Figure 4). Shooters 2H and 6H benefited from having mLoS closer to the opening than to the closing of the glasses – that is, the preferred phasing of mLoS of the shooters who actively negotiated the opening and closing of the glasses. Thus, besides the six participants who showed a preference for looking as late as possible given their shooting style, the shooting success of two participants benefited from being able to view the target as late as possible.

General discussion

Before turning to the main hypothesis, it is useful to stress that the occlusion technique used in the present study (i.e. intermittent viewing) did not affect the integrity of task performance. The shooting percentages realized under intermittent viewing were similar to those achieved under full vision, suggesting that participants were still able to pick up sufficient optical information about the target to successfully guide their shooting actions. Results from a previous study showed that having no vision during the entire shooting movement resulted in a deterioration of performance. In the no-vision condition of Oudejans *et al.* (2002), shooting percentages ranged from 0 to 32%, as opposed to an average of 61.5% in the full-vision condition. It should be noted that the intermittent viewing in the present study almost halved participants' normal viewing duration. Therefore, it is quite remarkable that expert shooters, regardless of the adopted shooting style, were still able to shoot accurately under the imposed visual constraints. The occlusion technique used was appropriate to examine the timing (or phasing) of

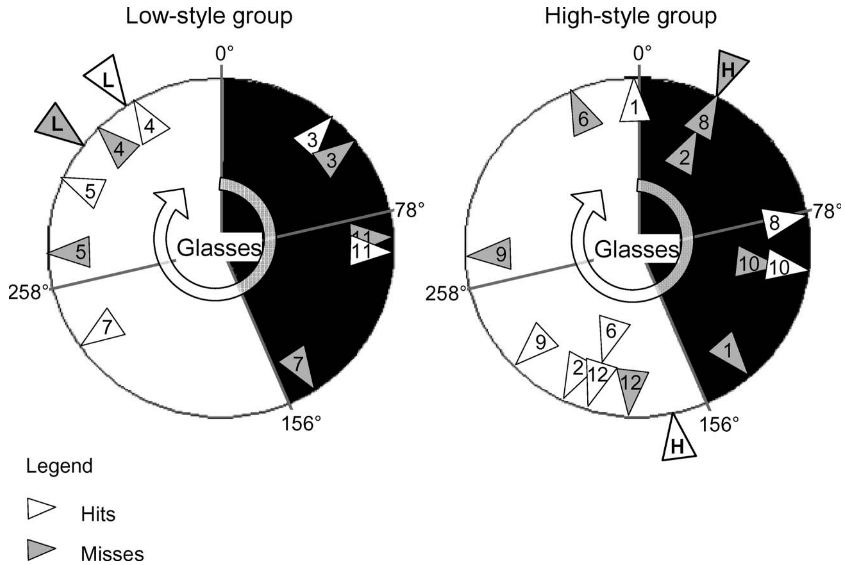

Figure 4. Circular average of mLoS across the cycle of the glasses for hits and misses of the low-style and high-style shooters, respectively. The letters in the outer triangles indicate group averages for hits and misses, while the numbers in the inner triangles represent the individual shooters to whom the averages correspond. Note that hits and misses of one shooter are close together when that shooter actively negotiated the phasing of the glasses.

optical information pick-up in expert basketball jump shooting, as was the aim of the present study.

Our hypothesis was that players prefer to look at the basket as late as possible given their shooting style. The group analyses fully supported this hypothesis. On average, both groups exhibited an active negotiation of the visual constraint, resulting in a non-random, group-specific distribution of the phasing of mLoS, such that the high-style shooters could see the basket just before ball release, whereas the low-style shooters could see the basket just before ball and hands passed the line of sight. Further analyses revealed that these group effects were reflected in the data of three low-style shooters and three high-style shooters. Finally, task success was dependent on the phasing of mLoS in two high-style shooters in a manner that was consistent with the "preference for looking late" hypothesis.

These results underscore the importance of the timing of optical information pick-up in dynamic far aiming tasks and qualify – or at least complement – the emphasis that is currently placed on the duration of gaze fixations in quiet eye research in the context of static far aiming tasks. In dynamic far aiming tasks like jump shooting, the opportunities for information pick-up are severely restricted in time due to the unfolding action itself and inherent neuromuscular delays. As a result, actors are forced to pick up the requisite information at an appropriate time at which the information in question is perceptually available and can be used in guiding the action. In the present study, we found that basketball jump shooters prefer to pick up optical information about the basket as late as possible given their adopted shooting style – that is, just before the basket is occluded by ball and hands (low style) or just before ball release (high style). In this regard, the visual guidance of basketball jump shooting abides by a common principle – picking up optical information as late as possible – which is independent of the adopted shooting style. It is important to note that, in the present study, long fixations were impossible due to the intermittent opening and closing of the glasses. The fact that shooting performance was not affected by this manipulation compared with full vision suggests that long fixations are not critical for the performance of the current dynamic basketball shooting task.

The present results also have a number of broader theoretical implications beyond the visual guidance of basketball jump shooting. We mention four. First, the identified principle of late optical information pick-up might generalize to dynamic far aiming tasks other than basketball jump shooting. As it stands, evidence for the importance of late optical information pick-up has been found in the context of several tasks, including racket sports (Caraugh & Janelle, 2002) and manual aiming (e.g., Elliott, Binstead, & Heath, 1999; Khan, Lawrence, Franks, & Buckolz, 2004), but may prove to be much more general if investigated in other task contexts. Second, the present results emphasize that goal-directed actions, such as basketball jump shooting, are not only guided by perceptual information but are also modulated online to facilitate pick-up of the requisite perceptual information, as emphasized in Gibson's (1979/1986) ecological approach and the corresponding notion of a perception – action cycle (Kugler & Turvey, 1987). Third, the present findings illustrate the resilience of the perceptual-motor system when dealing with visual constraints. Although this had already been demonstrated in studies of cyclical movements, which are predictable by virtue of their inherent periodicities (Amazeen *et al.*, 1999; van Santvoord & Beek, 1994), it had not been demonstrated before for discrete tasks involving aiming at a far target. Finally, the present study revealed marked individual differences in dealing with the visual constraints imposed, thus underscoring Bernstein's (1953/1996) notion of resourcefulness as a hallmark property of expertise.

In closing, it is useful to briefly discuss the implications of the present results for the currently increasing interest in perceptual training in sports. Research has established that perceptual-motor expertise is a key element of excellence in sports, and investigations are now focusing on the outcome of on-court training programmes designed to optimize this feature of expert performance (e.g. Adolphe, Vickers, & Laplante, 1997; Harle & Vickers, 2001; Williams, Ward, Knowles, & Smeeton, 2002b; for a review, see Williams & Ward, 2003). This development is important because training programmes in sports seldom pertain specifically to the pick-up of optical information. For basketball jump shooting, Oudejans *et al.* (2005) designed and implemented a visual training programme consisting of on-court and laboratory training which yielded positive results. They trained the pick-up of late optical information by letting high-style shooters shoot from behind a screen, thus forcing them to use only late optical information from the basket. A similar training exercise might be used for low-style shooters by letting them dribble past the screen and then perform a jump shot, in a single fluid movement. This permits the same setting to be used for training the pick-up of relevant late optical information taking into account the shooting style of the players.

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